TECHNICAL ISSUES AND ACTIVITIES FOR 50.46
RULEMAKING (REDEFINITION)

Technical Issues

The staff has developed a basic redefinition rule structure as outlined below (which corresponds more closely with a broad scope approach rule), which led to identification in many instances of the technical issues discussed herein. The technical issues below do not correspond directly to the issues listed because certain aspects will be covered by the rulemaking development, rather than in the technical basis development which is the subject of this attachment. The staff envisions that the rule would:

A. Define how the new design basis maximum break size is determined.

B. Define what it means under the rule to remove an event (large breaks, breaks without coincident LOOP) from the design or licensing basis, i.e., what such a removal means legally and technically with respect to current rule requirements, plant design, and plant operational limits.

C. Include criteria for assessing acceptability of facility changes to be made by licensees.

D. Include information to be supplied by a licensee about the analysis, methods, or other material to support the application.

E. Define the implementation process.

F. Define the conditions under which the allowed changes might need to be revised over the lifetime of the facility.

The staff anticipates that NRC review and approval will be needed for a licensee to modify its plant using an alternative maximum LOCA break size. The information to be reviewed would vary based upon the specific rule option chosen. With a broader scope rule, significantly more information would be required to be reviewed by the staff. The information to be reviewed would include information about the scope of licensee PRAs, and the quality processes applied. In addition, license amendments would also be necessary for some of the possible changes because technical specifications would have to be revised; however, the extent of the accompanying staff review would depend upon what was already established through the rulemaking.

TECHNICAL ISSUE AREA 1: Break Size Determination

The staff is scheduled to provide a Commission paper on March 31, 2004, presenting the re-estimation of LOCA frequencies. The paper will summarize the expert elicitation effort to develop LOCA break frequency distributions, including the elicitation scope and objectives. The analysis methodology and results will also be presented in context with previous results. The implications, applicability, and limitations of these results for rulemaking will also be discussed.

The March 31, 2003, SRM suggested that the selection of the alternate maximum break size could be developed from risk metrics such as some percentage of the total risk rather than the total risk from LOCAs. Identification of the most appropriate LBLOCA selection metric and numerical criteria will be developed as part of the technical basis associated with this issue. At this time the staff believes that the most appropriate metric to determine the design basis LOCA maximum break size is the direct LOCA initiating event frequency estimates (LFE) (being developed by the staff as noted above). The staff has to resolve several technical issues regarding break size determination in order to support an adequate rulemaking. The recommended values of LOCA frequency that would determine the maximum LOCA break size could vary depending on the rigor of other criteria in the rule and the scope of the rule. A LFE, which is based on the expected frequency of pipe breaks, is thought to be a more direct metric, unlike calculations of plant CDF or LERF that could vary significantly as new PRA methods are incorporated, plant modifications (other than those under this rule) are made, and other changes occur that affect plant risk. The staff believes it undesirable to have a process that either results in plant-specific break sizes or that can change over time due to many factors not directly related to break frequency. Regardless of the break size selection metric recommended, the staff will ensure that the process is risk informed and consistent with the principles of Regulatory Guide (RG) 1.174, as the Commission directed.

The staff is evaluating the technical issue of how far into the future the LOCA frequencies should be projected for a plant, given the projected 60 year life of many nuclear power plants. The staff is considering recommending projection beyond 10 years out be adopted. This would help reduce the potential for having to reverse changes and would reflect the large uncertainties associated with new piping degradation mechanisms.

The staff believes the selection of the new alternate maximum break size is of moderate complexity for either a narrow or broad scope rule approach. The role it plays in the overall rule and decisionmaking, and the means of dealing with the uncertainties is expected to be greater for a broad rule where more extensive changes to the plant might result.

Technical Issue Area 1 Resolution (Break Size Selection)

1. Determine the appropriate LFE value to use for identification of the corresponding redefined LOCA break size and identify what confidence level should be utilized in selecting the new break size. Utilizing the break size-frequency curves (developed from the RES expert elicitation process), identify the redefined LBLOCA size applicable to various categories of plants if a

generic definition is possible. If not, specify the plant specific implementation process necessary to determine the appropriate plant specific break size. (NRR lead)

Complexity: Moderate complexity for either narrow or broad scope approach.

2. Identify the level of mitigation appropriate for the selected LFE with respect to breaks above the redefined LBLOCA size. Identify the appropriate metric(s) to be used. This information will be applied as input for resolution of the mitigative measures technical issue (see activity 7 below). (NRR lead)

Complexity: Moderate complexity for narrow scope rule due to limited extent of changes. High complexity for broad scope rule due to potential for far reaching impacts on the plant's beyond design basis capability.

TECHNICAL ISSUE AREA 2: Plant Change Criteria

The Commission indicated in its March 2003 SRM that there should be regulatory oversight over the changes to the plant that would be allowed as a result of changing the maximum LOCA break size. It would be consistent with the philosophy of RG 1.174 to include plant change criteria associated with core damage frequency (CDF) and large early release frequency (LERF) in such a decision-making process. The staff has identified some technical issues[1] concerning selection of appropriate plant change criteria, control of plant changes allowed under the rule so that unintended changes and outcomes are not authorized, and selection of appropriate criteria to control plant changes under this rule where plant-specific total CDF estimates exceed certain limits. The staff believes that this area will be of moderate complexity for a narrow scope rule, and of high complexity for a broad scope rule.

The staff will address the technical issue of how to develop criteria, including the appropriate metrics, to determine if the proposed plant changes under this rule have an acceptable effect on estimated risk. The staff expects that in implementing the rule, once specific plant changes are postulated, the licensee would need to compare the effect of its proposed changes to the staff's criteria as a first step to determine if the plant change would be acceptable. To do this, a licensee would modify its PRA (or other risk assessment tools) to estimate the expected CDF and LERF increase or decrease if the changes were made. The licensee would then compare the calculated risk increase (or decrease) to the staff's criteria (likely to be delta CDF and delta LERF). The staff is considering establishing lower values for acceptable delta CDF and delta LERF estimates (as the values indicating the boundary between an acceptable and unacceptable change) for plants that do not have full-scope PRAs, and higher values of delta CDF and LERF for plants that have a full scope PRA or nearly a full scope PRA (e.g., a site in Florida might not need a seismic PRA due to the extremely low seismic hazard in the area). Lower values of acceptable delta CDF and LERF would reflect the higher levels of uncertainty due to the incompleteness of risk estimates developed for plants that do not have a full-scope PRA. Plants using risk assessment methods other than PRAs (e.g., the Fire-Induced

[1] The staff's preliminary conclusion is that the numerical criteria listed in RG 1.174 for defining acceptable changes to a plant's licensing basis are not stringent enough to use for modifying the fundamental building blocks and protections provided in the current regulations. Regulatory Guide 1.174 criteria for licensing basis changes are premised on a plant continuing to meet all the underlying regulatory requirements set out in the NRC's regulations even as changes made may result in a small increase in CDF or LERF.

Vulnerability Evaluation (FIVE) fire methodology) would need to justify that the methods used produce realistically conservative numerical results and appropriate safety insights compared to full-scope PRAs and would need to use sufficiently conservative risk assessments in their delta risk calculation, or would need to justify that the method is capable of accurately determining the expected change in CDF or LERF.

The staff will address the technical issue of how to control changes under the rule. If a narrow scope rule were promulgated that specified the only allowable changes, the effort to prevent unintended outcomes would be significantly lessened. The downside of this type of rule is that the changes allowed would probably be limited, given the current technical basis for changes that is available to the staff. If a decision was made to promulgate a broad rule, it would be significantly more challenging to develop risk informed requirements that assure plant changes do not result in unintended outcomes. The staff will develop criteria that must be able to withstand technical and legal scrutiny as to their specificity to limit unacceptable changes. The staff will seek to develop criteria that provide this assurance with reasonable NRC and industry resource expenditures.

The staff will address the technical issue of how total plant risk (i.e., CDF and LERF) should be factored into the risk-informed decision making process under this rule. The staff believes that plant modifications made under this rule should be limited if the total CDF at a plant exceeds a threshold (similar to the process for licensing basis modifications using RG 1.174). The staff will determine this threshold and will address how plants without a full scope PRA should estimate their total CDF. It is the staff's intention to provide additional benefits to licensees that have invested the resources to develop a full scope PRA.

As discussed in this paper, the staff seeks Commission direction on the issue of functional changes. The March 2003 SRM stated that the Commission does not support changes in functional requirements unless they are fully risk-informed. One option on functional changes is for the Commission to not allow any functional changes, such as changes to flow rates of ECCS pumps or other "natural changes" such as extensive power uprates, changes to core thermal limits, or reduced capability of accumulators. However, it is unclear if there would be any industry interest in such a rule, as its application would be very limited. Such a limitation would provide the most assurance that no significant degradation of the underlying protection of a power plant's design bases was allowed by the rule. A second option is to allow fully risk-informed changes to equipment function. Here, by fully risk-informed, the staff means meeting a process similar to that outlined in RG 1.174 including assurance of defense-in-depth and safety margins (See discussion of defense-in-depth). The staff believes that the technical and safety implications of allowing fully risk-informed plant changes are significant and need to be carefully considered, but that with appropriate resolution of the technical issues, the broad scope rulemaking offers the potential to be a useful, safe, alternative set of requirements.

Technical Issue Area 2 Resolution (Plant Change Criteria)

3. Develop criteria, including the appropriate metrics, to help assure the proposed plant changes have an acceptable effect on estimated risk. Develop guidelines or criteria for plants with less than full scope PRAs. Criteria must be specific enough to limit unacceptable changes. (NRR lead)

Complexity: Medium complexity for a narrow scope rule; high complexity for a broad rule.

4. Develop criteria to factor total CDF into the decision-making process such that plant changes are limited if total CDF exceeds some threshold. Criteria must account for plants that have less than full scope PRAs. (RES lead)

Complexity: Moderate complexity for both narrow scope or broad rule approaches.

TECHNICAL ISSUE AREA 3: Defense-in-Depth

Retention of adequate defense-in-depth is an important technical issue when changing the fundamental bases on which most nuclear power plants were designed and built. Defense-in-depth is a philosophy adopted by the NRC to help address uncertainties and unknowns. The defense-in-depth philosophy has evolved over time to address multiple barriers to radionuclide transport, including the fuel, coolant pressure boundary, and containment, and the introduction of engineered safety features to perform a set of safety functions whose ultimate objective is to protect the integrity of these barriers.

The staff believes it is important to take advantage of the guidance already approved by the Commission in Regulatory Guide 1.174, but it may be necessary to further define and expand the guidance for this application. The RG lists seven criteria for maintaining defense-in-depth (of which six of the criteria are pertinent to risk-informing 10 CFR Part 50): maintaining a reasonable balance among prevention of core damage, prevention of containment failure, and consequence mitigation; avoiding over-reliance on programmatic activities to compensate for plant design weaknesses; retention of redundance, independence, and diversity commensurate with risk; defenses against common cause failures; independence of barriers; and defenses against human errors. Resolution of the issues in this area would be of moderate complexity for a narrow-scope rule, and of high complexity for a broad-scope rule, because of greater potential to affect defense-in-depth when more substantive changes to a plant occur.

The staff will evaluate the technical issue of whether the defense-in-depth criteria in RG 1.174 need to be expanded given that the rule under consideration would potentially revise fundamental protections provided in the current regulations. The RG 1.174 process assumes the underlying regulations are not changed and are always satisfied. The staff's product of this evaluation will list any additional criteria beyond those criteria already documented in RG 1.174 needed to assure adequate defense-in-depth. If the staff's evaluation determines that additional criteria are needed, the staff will request Commission approval to include the criteria in the rulemaking.

Technical Issue Area 3 Resolution (defense-in-depth)

5. If needed, provide additional criteria beyond those already in RG 1.174 to assure adequate defense-in-depth. (NRR lead)

Complexity: Moderate complexity for narrow scope rule. High complexity for broad scope rule approach.

6. If needed, provide guidelines on how to meet the defense-in-depth criteria already in RG 1.174 for changes resulting from this rulemaking. (NRR lead)

Complexity: Moderate complexity for narrow scope rule. High complexity for broad scope rule approach.

TECHNICAL ISSUE AREA 4: Assessment of Mitigation Capability

Another technical issue to be decided, based upon the extent of application of redefinition, is how to select success criteria for determining mitigation capability for LOCA sizes between the new maximum large break LOCA and the DEG break of the largest pipe in the system. These issues would be of moderate complexity for a narrow-scope rule, and of high complexity for a broad-scope rule because of the potential for changes to impact capability to mitigate beyond design basis events.

The staff will evaluate the technical issue on the need to mitigate breaks beyond the new LBLOCA size. The staff will develop criteria for determining if mitigation capability is adequate for LOCAs between the new maximum design basis LOCA size and the DEG break. In addition, the staff will determine how such mitigation should be incorporated into the regulatory process. Depending on the type and degree of plant modifications sought by industry under this rule, the criteria to assure appropriate mitigation of LOCAs between the new maximum design basis LOCA and the DEG break could vary. For some plants the mitigation criteria might be as simple as using best-estimate (realistic) thermal hydraulic models (acceptable to, but not formally endorsed by the NRC) to demonstrate that no core damage occurs. Other examples of potential mitigation criteria include increasing the peak cladding temperature limit, defining limits on the percentage of fuel melt or fuel pin failure that would be allowed, or defining limits on permissible clad oxidation. The objective of these alternatives is to provide confidence that a LOCA greater than the new maximum design basis is not expected to result in reactor vessel failure and early containment failure.

The staff is working in parallel on consideration of whether it is feasible to develop a revised ECCS success criteria for breaks beyond the new maximum design basis LOCA size, which will maintain a coolable fuel geometry. The staff does not expect to formulate a recommendation for how such criteria should be regulated, if at all, until the technical issues associated with mitigation are more fully developed.

The staff also seeks to assess the consequences of a DEG LOCA if a plant were uprated and the mitigating system performance were not kept at the level currently required for a DEG break. The staff is also calculating the contributions to CDF from redefining the maximum design basis LOCA size and making some of the modifications suggested by stakeholders. RES efforts are ongoing and draft reports will be available in the 4th quarter, FY 2004.

Available codes at the state-of-the-art level may need additional benchmarking against the phenomena associated with arresting a core melt. RES is performing thermal hydraulic sensitivity cases to evaluate the changes in CDF. These evaluations should take into account the changes in safety margins and defense-in-depth features based on other RES analyses. RES efforts are ongoing and are considered draft at this time (preliminary due-date of 4th quarter, FY 2004).

It has been postulated that it might be useful to place guidance on acceptability of mitigation capability for breaks between the new maximum design basis LOCA and the DEG break into the severe accident management guidelines (SAMGs) at plants. It has already been noted that

there will be large uncertainties in the estimated frequency of the breaks removed from the design basis. It should be noted that the SAMGs are entirely voluntary on a licensee's part, and may be removed by a licensee without NRC approval. Additionally, the SAMGs focus largely (but not exclusively) on post-core damage actions including operator recovery actions. The staff believes it may be more appropriate that the mitigative guidelines result in plant system capability such that vessel failure and large early release are not expected for LOCAs greater than the new maximum design basis LOCA break size. Were reliance to be placed on use of SAMGs for redefinition, there would likely be a need for some type of regulatory control on severe accident management guidelines and procedures.

Technical Issue Area 4 Resolution (Mitigation for Beyond Design Bases LOCAs)

7. Develop a list of criteria to be met (and the technical basis for the criteria) to demonstrate adequate mitigation capability for LOCAs beyond the new maximum design basis LOCA up to the DEG break. (RES lead)

Complexity: Moderate complexity for narrow scope rule. High complexity for broad scope rule due to the potential for far reaching effects on the plant's beyond design basis capability.

TECHNICAL ISSUE AREA 5: Cumulative Effects

The staff anticipates that licensees will make several, if not numerous, modifications to the plant over an extended period while implementing this rule. Each modification to the design or operating characteristics of a plant can change the risk profile of the plant and the effect of all plant modifications arising from redefining LOCA size should be identified and tracked over the life of the plant. The staff will address the technical issue of how the cumulative effect on risk from all the modifications enabled by redefining the LOCA size should be monitored and controlled. In a narrow scope rule, the potential for cumulative effects to be significant is low. A broad scope rule would necessitate consideration of enhanced management of cumulative effects.

Experience from the review of numerous risk informed submittals has demonstrated that tracking the cumulative effect on risk of plant modifications made to a plant is complex. One aspect is that PRA upgrades (whereby nothing in the plant is changed but the PRA models are improved) can increase or decrease the risk associated with a particular SSC or procedure modification. Often, PRA upgrades are made in parallel with updates to the PRA to reflect the modifications to the design or operating characteristics of the plant. It often is difficult to determine if the net change in CDF or LERF is due to the PRA upgrade or actual modifications made to the plant. The commingling of these changes provides a complexity to the accounting of changes in risk. Similarly, modifications over time to the plant and the PRA upgrades may decrease or increase the estimated change in CDF or LERF associated with previous plant modifications.

Monitoring of the change in risk associated with each PRA and plant change has been considered and discussed with industry but has been recognized by both industry and staff as resource intensive. Today, most risk-informed applications (i.e., allowed outage time extensions, inservice inspection, containment leak rate testing) have application-specific processes to ensure that cumulative changes in risk arising from the authorized modifications

are controlled. Cumulative effects of the many different, and potentially substantial, modifications with broad scope changes to the LBLOCA licensing basis will be difficult to assess. A systematic process will require development of analysis guidelines that yield a well defined cumulative risk estimate for all the individual changes authorized by the rule over the life of the plant.

Technical Issue Area 5 Resolution (Cumulative Effects)

8. Determine the information that needs to be tracked for the individual changes authorized by the rule over the life of the plant. Develop analysis guidelines that yield well defined cumulative risk estimates that can be compared to the applicable risk criteria. Develop guidelines for evaluating the cumulative changes against the defense in-depth and other qualitative guidelines. (NRR lead)

Complexity: Moderate complexity for a narrow scope rule because of the limited number of potential changes. High complexity for a broad scope rule, because of issues related to the changing plant risk baseline and different contributions from PRA methodology changes vs. physical plant modifications.